Tactical Data Links and Interoperability, The Glue between Systems

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ABSTRACT

In this time of open system architectures, systems of various makes and origin co-operate, pass, and share pieces of information. The pieces of information, thus exchanged, should trigger the same understanding by all users. Ambiguities in the translation, presentation, or interpretation of the data and information may be the cause of serious problems. This paper addresses some of the aspects of interoperability and describes ways of achieving, monitoring, and maintaining inter-operability in particular for tactical datalinks such as Link 11 and Link16. Emphasis is given to tactical data link interoperability with the NATO E-3A.

KEYWORDS

Interoperability, Tactical Data Links, NATO Standards Agreements, STANAGs.

1 INTRODUCTION

Military systems don't operate in isolation. There is a strong requirement, even a mandate, to be interoperable with other military systems or civil systems. Interoperability can be defined as the ability of systems to provide services to and accept services from other systems and to use the services so exchanged to enable them to operate effectively together [AAP-6].

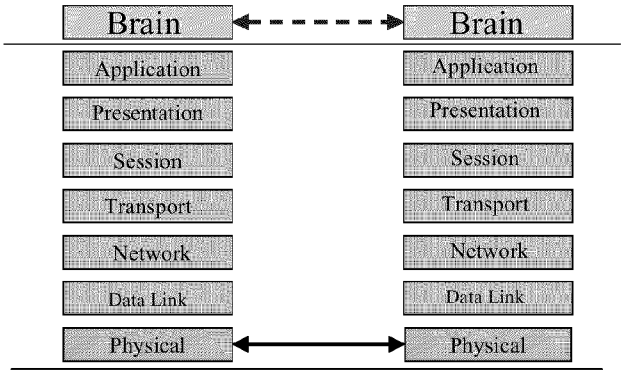
Interoperability is the glue that keeps operators, systems, units and forces and operations together. Interoperability does not depend on hardware, software and crew proficiency alone but must be supported by adequate operational procedures and training.

In this paper we describe various ways to describe interoperability and methods to achieve interoperability in the sense defined above. We will start in paragraph 2 of this paper with an extension of the well-known OSI (International Standards Organisation) 7-layers model. In paragraph 3, the formal agreements and procedures to achieve interoperability on tactical datalinks within NATO are addressed. In paragraph 4 we describe ways to achieve, monitor and maintain interoperability. In paragraph 5 the NATO Interoperability Environment Testing Infrastructure (NIETI) is described. In paragraph 6 we describe the plans for future work at NC3A and in 7 we focus on one particular aspect of these plans. Paragraph 8 addresses the management of tactical data links and finally the paper is summarised in paragraph 9.

2 EXTENSION OF THE OSI MODEL

We can describe interoperability in the terms of the OSI 7-layers, defining the layers that exchange data with one another.

Paper presented at the RTO SCI Symposium on "System Concepts for Integrated Air Defense of Multinational Mobile Crisis Reaction Forces", held in Valencia, Spain, 22-24 May 2000, and published in RTO MP-063.



Extension of the OSI 7 Layers

Physical data exchange takes place at the lowest layer, via data-busses, telephone lines or radio links. The technical exchange, i.e. encryption, error correction etc. and the link management occur in the Data Link and Network layers. The procedural interoperability is performed in the four upper layers. The Transport layer performs the correct exchange of messages with functions such as receipt/compliance. The Session layer takes care of the proper sequencing of the message. The Presentation layer formats the messages. In the Application layer the messages or data are presented to the host and via the Man Machine Interface to the operator. The Brain-to-Brain layer, which represents operator interoperability, is essentially a layer above the Application layer and therefore beyond the OSI 7-layer model.

3 STANAGs, ADatPs AND PRACTICAL INTEROPERABILITY

Most of the lower level technical interoperability requirements for tactical datalinks are defined in Standard NATO Agreements, STANAGs. Mere STANAG compliance is often used as a definition for being interoperable. In practice however, STANAG compliance is just a necessary condition and STANAG compliance alone is not sufficient to guarantee inter-operability. The operational use of systems defined by STANAGS, is described by Allied Data Publications, so-called ADatP's, defining the applicable operational procedures. In many cases, however, ADatP's do not follow day to day military practice and lag behind in their description of the actual procedures used. The consequence is that many military systems, which are assumed to be interoperable by design, fail in practice in being fully interoperable amongst themselves or with other systems.

Military systems should also operate on a non-interference basis or be interoperable with civil systems, for example, JTIDS message exchange takes place in the radio-navigational frequency band and is only permitted on a non-interference basis. The JTIDS band will be used by a new GPS frequency and the European Community Project Galileo is also aiming at its share of this frequency band.

Within the NATO Consultation, Command & Control Agency (NC3A), the Air Command and Control Division (ACD) Surveillance Branch looks at the tactical datalinks such as Link16, IJMS and Link11 and the messages exchanged between the various Air Command & Control (C2) components in the NATO Nations.

This has been particularly interesting during the past years for the three new NATO nations, the Czech Republic, Hungary, and Poland. NC3A has played a key role in integrating their national Air C2 systems into the NATO Integrated Air Defense System (NATINADS). After the recent experience in Operation Allied Force, in which SHAPE and SACLANT rented the UK DERA TIM/MIDAS equipment to monitor tactical datalinks, it has become clear that such on-line monitoring of multi-tactical data links is an operational requirement.

4 ACHIEVING INTEROPERABILITY

Assume for the moment that we have systems, which are STANAG compliant, and where the ADatP's, to the best of our knowledge, describe actual operations adequately. Rather than focussing strictly on technical inter-operability, we also focus on the aim of the system. Do we achieve our military goals, or not? If we don't achieve the military goals, we may have an inter-operability problem. In this paragraph several ways to address potential or actual IO problems are reviewed.

4.1 Paper Analysis

The first step to achieve inter-operability is to perform detailed analysis on system implementation, behavior and performance. Analyze the proposed or actual implementation and compare it with the STANAGs, ADatPs and similar systems. Many potential interoperability problems can be caught early during the development phase of the system with this kind of analysis. This approach has been used in the UK and it enables the discovery of potential interoperability problems at an early stage.

4.2 Prototype Testing

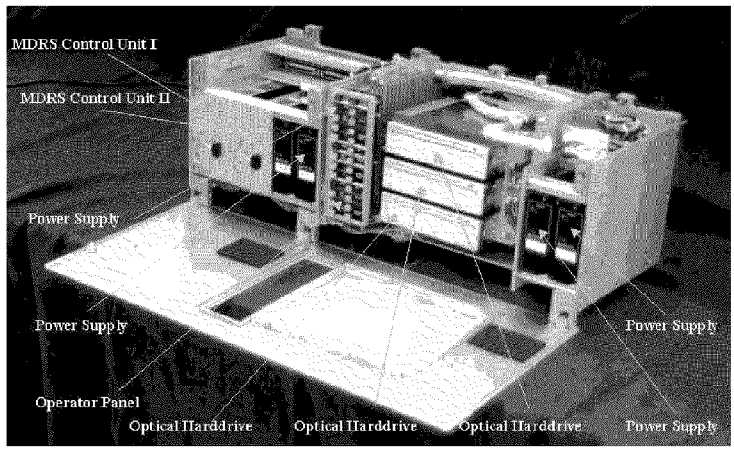
Testing a prototype of a system to verify its functioning against the various systems, with which the actual system might be required to operate, is the next step. Once it is thoroughly tested and verified, such a prototype could be used as a reference system for testing and validation purposes when the actual systems become operational. A problem is however the availability of operational systems against which a prototype can be tested. In many cases this requires specially scheduled flights. NATO has developed an approach to test the functional interoperability of systems via telephone lines using STANAG 5602, the Standard Interface for Multiple Platform Evaluation (SIMPLE). A first successful demonstration of this protocol took place in April 1999 and the next demonstration is planned in April 2000.

4.3 Live IO Problems

It is often necessary to analyze a live interoperability problem. In such a case, we have to trace the whole set of events leading to the problem through all systems involved. This may require data recording at all possible interfaces as well as availability of appropriate data reduction and analysis tools. This seems a sensible statement, but many military systems are not (yet) built in such a way that adequate data monitoring is possible. It adds to system complexity. Although it may be a requirement during development and testing of the system, it is often de-scoped for the final fielded equipment. Some examples of improved recording capabilities for the NATO E-3A are mentioned below.

4.3.1 AORTA Recording

During the recent years, the NATO E-3A community has formulated an urgent requirement for a replacement of the outdated, failure-prone and inefficient 800 BPI Magnetic Tape Transport (MTT)-based Mission Data Recording System (MDRS) in the NATO E-3A, which could not meet the new recording requirements (loss of up to 50% data recording). NAEW Force Command tasked NC3A to develop a replacement MDRS. The new NATO MDRS is a "plug & play" system with a virtually unlimited recording capacity due to the use of magneto-optical media and with a recording speed which is at least 5 times that of the old system. The integration of the NC3A developed MDRS does not entail any system baseline changes. The entire NE-3A fleet was retro-fitted with the new MDRS in fall '99.



AORTA Recording Equipment

4.3.2 Voice Recording

A 10 channel voice-recording and replay prototype was also developed on behalf of NAEW Force Command. This system used the latest technology (MPEG-2, layer 3 perceptive noise shaping techniques) and was successfully demonstrated with a live mission recording.

4.3.3 ESM Data Recording

Special ESM recording equipment, developed by NC3A, was successfully demonstrated in January 2000.

4.3.4 Online Reduction

As a future requirement we see a need for on-line reduction and analysis of all data recorded. Analysis of flight data is currently performed off-line, after the flight and on request. Release of the classified data can take time as well.

4.4 Inter-System Performance Monitoring

The other problem is that online monitoring and reduction of inter-system performance is difficult. It requires special equipment, skills and manpower and is costly. Nevertheless, it is often cost-effective when compared to the risks and investment in an operation or exercise.

Apart from providing military systems with an adequate recording capability, one should have the possibility to simulate system behavior in a controlled environment. This requires a substantial validation of the simulation system to be sure that actual operations are mimicked adequately (here the presence of the validated prototype equipment becomes very useful). Experience to date with the new NATO nations showed that it was necessary to test the data links using prototype systems at NC3A. For instance, the ASTERIX protocol is highly complex and implementations by different systems, in this case EUROCONTROL and the Air Sovereignty Operations Center (ASOC) system were not consistent at the Presentation layer.

At NC3A, a number of testbeds already provide a monitoring and a simulation capability for the integration of the new NATO nations air defense assets into NATINADS. Other equipment, such as the Deployable ERCS Prototype Terminal (DEPT), is easily transportable and is used to support real operations. It could be used to provide the monitoring and analysis support for interoperability assessment as well.

Monitoring interoperability requires adequate recording, reduction and analysis capabilities. For mission critical systems, such as tactical datalinks, the presence of online monitoring facilities is almost a must, certainly in the early phases of their operational usage. Experience between the US and the UK as well as NATO experience with Link16 showed that the presence of a monitoring and analysis capability, which spotted problems, was able to provide adequate solutions or work-arounds in many cases in near real time. The monitoring capability may also be used as a hot stand-by or perhaps even as an initial deployable asset.

The ability to investigate and solve interoperability problems in near real-time and extract data from recorded tactical datalinks was demonstrated when NC3A tested the UK DERA TIM/MIDAS equipment [ACE99] on behalf of the SHAPE Bi-SC Datalink Management and Interoperability Cell (DLMIC) for the first days of exercise Central Enterprise '98 at Wilhelmshaven (GE) and when SHAPE rented this equipment to monitor Operation Allied Force from Lecce (It).

Specific systems and tools to perform on-line data analysis in support of interoperability assessment are available from various vendors for different applications. Apart from the TIM/MIDAS equipment, referred to above, other systems are in use and will be evaluated in the near future. A concept of operation for monitoring Link16 operations was recently developed and it is expected that this concept of operation for a Deployable Operational Multi-Link Integration Network Management and Interoperability Evaluation System (DOMINIES) will be endorsed within a short time.

4.5 Training

Complex systems like tactical data links do require adequate training. Too often, the operational community considers the tactical data link terminal as a mere radio and does not put sufficient effort in the proper training and exercising of the tactical data link operators. Inexperience and lack of training are two important causes of interoperability problems.

4.6 Impact Assessment

Once an IO problem is discovered, the operational community has to make an assessment of its impact. This assessment will be the prime driver for prioritizing the solution of the problems or the finding of appropriate work-around. Knowledge of existing IO problems, their impact and possible work-arounds helps to improve interoperability.

5 THE NIETI PROJECT

NATO is investigating approaches to develop a NATO Policy for C3 interoperability. This NATO Policy for C3 interoperability will be executed by means of the NATO IO Management Plan (NIMP) [Vogt99] and a Rolling Inter-operability Plan (RIP). The product will be the NATO Common Inter-operability Standards (NCIS) to be used in the NATO C3 Common Operating Environment (NC3COE). The actual development and testing is planned to be performed by the NATO Interoperability Environment Testing Infrastructure (NIETI) and this body should assume responsibility for NATO-wide C3 interoperability testing using national and NATO organic systems. The NIETI Project Team is investigating the feasibility of this concept and it will report in February 2000. NIETI could perform many of the higher level interoperability test activities. It would provide a focal point for any questions and problems on high-level interoperability. The NIETI could also maintain a NATO-wide database of known IO problems. Many interoperability problems occurring in day to day practice are not easily tested and systems thus require continuous monitoring.

NIETI will rely on national and NATO organic systems. Many of the NATO organic systems exist already, either as prototype or in final form at NC3A, The Hague, and could be used for interoperability testing. A specific example is the Enlargement Air C2 & Surveillance Testbed (EAST) used for RAP and C2 system interoperability testing.

6 FUTURE WORK AND THE WAY AHEAD

The ACD-Surveillance Branch at NC3A performs prototyping and testing of RAP & C2 systems. Many of these systems intercommunicate by means of tactical data links such as Link1, Link11, Link 11B and Link16. The ACD Surveillance laboratory contains many of the C2 systems used within the new nations and acts as a natural focal point for the high-level interoperability testing of tactical datalinks. This requires appropriate terminal equipment, a representative host system and crypto equipment to operate with external systems and testing agencies.

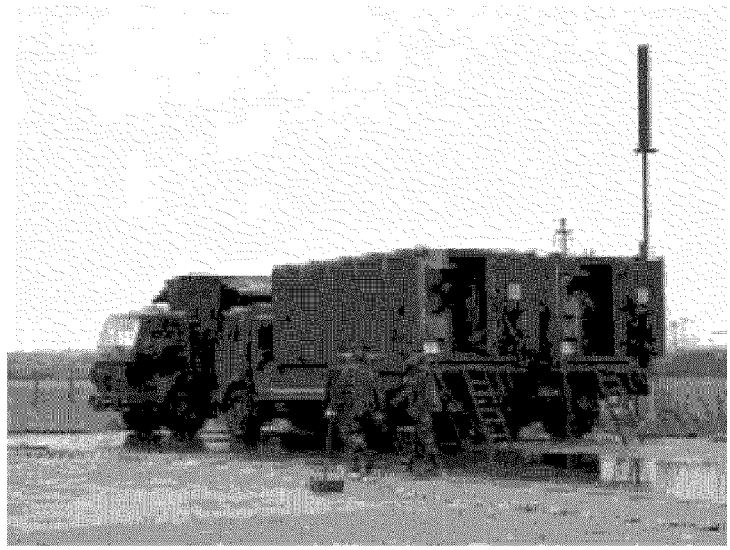
In addition, the Surveillance Branch employs the Deployable ERCS Prototype Terminal (DEPT) a truck-mounted shelter, equipped with a JTIDS Class 1 terminal and a means to process, record and pass the received air-picture to remote users. The DEPT is currently used to support exercises by providing the E-3A derived recognised air-picture (RAP) to ground sites not equipped with JTIDS and it acts as a positional reference for out of area operations of the NATO E-3A.

This DEPT could be the nucleus for a future deployable NATO tactical data link monitoring and test system. To perform this task, it should be equipped with a bilingual Class 2 or a MIDS terminal, with Link 11 equipment and with a STANAG 5602 (SIMPLE) compliant interface. It should contain a host system and MMI able to provide the necessary messages and interaction to stimulate and monitor the datalinks under operation or test. It would be a prototype for the DOMINIES system, which would provide on-line JTIDS net management and monitoring for the resolution of interoperability problems which cannot be foreseen in laboratory testing. The upgraded DEPT would be the operational counterpart to the high-level inter-operability testing performed in laboratories at agencies like NC3A and national facilities. In particular the assessment of the higher layers of interoperability testing, i.e. the human- machine -interface (HMI). The unambiguous interpretation of data link messages at the so-called brain-to-brain level could be tested with such a deployable system in an operational multi-tactical data link environment.

NATO will be operating in a multi-link environment, which will pose special interoperability problems. "Racing" conditions can disrupt the integrity of information in systems employing multiple datalinks, i.e. the same information is received in different formats, at different times and perhaps slightly modified over different data-links. How will it be processed? Who has reporting responsibility? What source should be selected? How do we merge these data? These are just a few of the questions that will require solution.

7 USE OF THE UPGRADED DEPT

The new NATO nations have a requirement to receive the E-3A air picture. Various methods to implement this requirement exist and vary from Receive Only Link11 (ROLE) to a full Link16 implementation. The DEPT would be used to initially demonstrate the capabilities of such implementations. It would also provide adequate means to test and debug an implementation because airborne assets able to provide a NAEW picture are expensive will not be available on a day to day basis as required for testing or implementation. The DEPT will also provide an efficient means to test ACCS sites during the acceptance phase. These sites are in general not within line of sight from one another and therefore have to rely on airborne assets, like the NATO E-3A, to provide Link16 data during their implementation and acceptance testing. Equipment such as the DEPT upgrade will be used to provide the required test inputs to test the ACCS systems. Moreover, due to the on-line analysis and replay capabilities embedded in the DEPT, test results can be made available almost immediately instead of having to wait days or weeks before recordings are reduced and released for comparison. The DEPT is available 24 hours a day and analysis data can be produced almost immediately, correction of interoperability problems of a technical or procedural nature, can be undertaken without undue delay. The schedule risk in implementing tactical datalinks for the Mid-Term upgrade of the NATO E-3A, ACCS or the new NATO nations will be decreased substantially.



The DEPT in operation

8 MANAGING INTEROPERABILITY

The management of interoperability requires preparation well before the operation/exercise and a monitoring and management capability during the operation or exercise.

Preparation depends on specific interoperability requirements and should be performed as much as possible hand in hand with the preparation of the Air Tasking Order (ATO). It could mean that frequency selection and co-ordination has to be performed as in the case of Link11 or that a JTIDS network has to be designed to cater for the individual cross-tell requirements of the participating units. In the case of a JTIDS net consideration has to be given to national frequency constraints, which are imposed on the use of the JTIDS frequencies by various nations.

Live operations require a monitoring and management capability. This monitoring and managing capability can be performed in the current airborne platforms or in ground-based platforms. In the case of problems and their subsequent analysis, a fast reduction of the data-recording is a must. We foresee that online data-reduction and tactical data ink monitoring and management equipment will be part of the next generation of assets.

9 SUMMARY

In this short paper we provided an overview of the methods to achieve and maintain interoperability. We described the paper analysis, which will solve many problems right from the beginning and the follow-on activities such as the development of prototype systems, the use of prototype systems during system implementation and acceptance and the need to manage and monitor interoperability. We provided reference to NATO and NC3A activities in this field.

In this paper, we have shown that interoperability at all levels, including the brain-to-brain level, must be examined and monitored to achieve complete inter-system interoperability. Finally we want to emphasise the fact that interoperability provides the glue between systems.

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